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(54) **Insulated mold structure with multilayered metal skin.**

(57) A multilayered insulated mold structure is provided. An insulation layer provided on the mold base retains heat at the molding surface, thereby increasing surface smoothness of the molded part. A multilayered skin layer (14) is provided on the insulation layer. The skin layer comprises a plurality of sublayers which are designed to provide improved adhesion, mechanical strength and abrasion resistance.

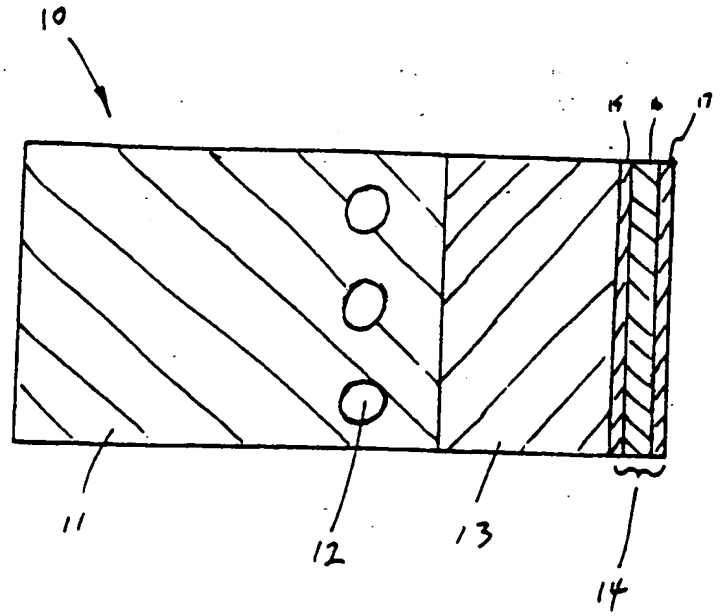

FIG. 1

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proved qualities are achieved by providing a plurality of skin layers on the insulating layer instead of a single skin layer. The abovementioned co-pending application, Serial No. 07/437,051 describes the use of a multilayered skin layer. However, in Serial No. 07/437,051, the mold structure is only partially insulated and the multilayered skin is provided in order to prevent delamination of layers caused by different coefficients of thermal expansion.

In a preferred embodiment of the present invention, three skin layers are placed successively on the insulating layer. A thin layer of metal which exhibits good adhesion to the insulating layer is deposited first, directly to the insulating layer. A layer of metal chosen to provide mechanical strength is then placed on top of the first layer. Finally, an outer layer having superior abrasion resistance is deposited.

In accordance with a further embodiment, the present invention comprises two outer skin layers disposed on the insulating layer. By selecting proper combinations of materials, the two-layer embodiment can possess the desired characteristics of good adhesion, strength and abrasion resistance of the three-layer embodiment.

It is therefore an objective of the present invention to provide an insulated mold structure which produces molded parts with smooth surfaces in short cycle times.

It is a further objective of the present invention to provide an insulated mold structure having improved adhesion between the insulating layer and skin layer, improved mechanical strength and improved abrasion resistance.

Brief Description of the Drawing

The subject matter which is regarded as the invention is particularly pointed out and distinctly claimed in the concluding portion of the specification. The invention, however, both as to organization and method of practice, together with further objects and advantages thereof may best be understood by reference to the following description taken in conjunction with the accompanying drawing figures in which:

Figure 1 is a partial side elevation in section of a preferred embodiment of the mold structure.

Figure 2 is a partial side elevation in section of another preferred embodiment of the mold structure.

Figure 3 is a graph showing the transient temperature response in blow molding processes in molding apparatuses with and without insulation.

Detailed Description of the Invention

Referring now to the drawings wherein like numerals indicate like elements throughout, Figure 1 shows a partial side elevation of the multilayer mold 10 of the present invention. The mold 10 comprises a mold base or core 11 of high thermally conductive material. Cooling lines 12, such as copper pipes, are provided in the core for receiving a cooling fluid to reduce cycle time. The core 11 is covered by a thin thermal insulating layer 13. The thermal insulating layer can be fabricated from low thermally conductive material such as high temperature thermoplastics, thermosets, plastic composites, porous metals, ceramics and low-conductivity metal alloys. Other low thermally conductive materials used for insulation could also be used. Because the insulating layer is often not mechanically strong and cannot produce surfaces of high quality when used as a mold surface, a thin hard skin layer 14 is bonded to the insulating layer. The skin layer must exhibit a number of desired properties. These properties include strong adhesion between the skin layer and the insulating layer, good abrasion resistance and high mechanical strength. Other important properties include thermal conductivity and oxidation resistance.

To achieve these properties, the hard skin layer is fashioned from a plurality of sublayers which contribute one or more of the desired properties. In a preferred embodiment, the "tailored" skin layer comprises three sublayers. A thin sublayer 15 is first disposed directly onto the insulating layer. This first, inner sublayer 15 is made of a material which exhibits good adhesion strength as well as thermal conductivity and oxidation resistance. Examples of such materials are Enthone electroless nickel 422 and Shipley electroless copper 250. Next, an intermediate sublayer 16 is disposed on the inner sublayer. The intermediate sublayer must provide a high degree of mechanical strength and thermal conductivity. Examples of preferred materials for the intermediate sublayer are Lea Ronal electrolytic nickel PC3, electrolytic copper and Enthone electroless nickel 426. Lastly, a thin outer sublayer 17 is disposed on the intermediate level. The outer sublayer provides superior abrasion resistance. Preferred materials for accomplishing this are Enthone electroless nickel 426, Englehard electrolytic palladium nickel 80/20, TiN and chromium. Ideally, the inner and outer sublayers are 1 to 25 microns in thickness, while the intermediate sublayer is 25 to 250 microns thick to enhance mechanical strength.

The result of these three sublayers is a thin hard skin layer which has a smooth, hard molding surface as well as good adhesion strength, structural integrity and abrasion resistance. The insulating layer 13 and the hard skin layer 14 can be applied, for example, by lamination, deposition or sintering. The high conductivity core 11 provides

dotted line represents the response in the conventional mold. As seen in the Figure, the parison in the apparatus without insulation is immediately cooled below the glass transition temperature, T_g. Such rapid cooling will cause rough surfaces. On the other hand, with the insulated mold structure, the parison surface is initially quenched by the cool skin and temporarily falls below the glass transition temperature, but the surface is then reheated by the hot melt from within the molten plastic layer. Since the surface temperature increases to above the glass transition temperature, the resin fills and duplicates the mold surface, thereby avoiding rough surfaces.

From the foregoing description, it will be seen that the present invention provides an improved molding apparatus which is applicable to many types of molding processes including injection, compression and blow molding. Existing molding devices can be easily adapted to incorporate the present invention without great effort or expense.

While the invention has been particularly shown and described, it will be understood by those skilled in the art that various changes in form and detail may be made without departing from the spirit and scope of the invention.

Claims

1. A multilayer mold for molding thermoplastic into finished parts comprising:
   a core;
   an insulating layer bonded to said core for slowing initial cooling of the thermoplastic during molding; and
   a skin layer bonded to the insulating layer, said skin layer being formed from a plurality of sublayers.

2. The mold of claim 1 wherein at least one of the plurality of sublayers provides abrasion resistance.

3. The mold of claim 1 wherein at least one of the plurality of sublayers provides adhesion strength.

4. The mold of claim 1 wherein at least one of the plurality of sublayers provides structural integrity.

5. The mold of claim 1 wherein the plurality of sublayers comprises first, second and third sublayers.

6. The mold of claim 5 wherein the first sublayer is bonded directly to the insulating layer, the second sublayer is bonded on top of the first sublayer, and the third sublayer is bonded on top of the second sublayer.

7. The mold of claim 5 wherein the first sublayer comprises a material which provides strong adhesion between said skin layer and said insulating layer.

8. The mold of claim 5 wherein the second sublayer comprises a material which provides structural integrity.

9. The mold of claim 5 wherein the third sublayer comprises a material which provides a high degree of abrasion resistance.

10. The mold of claim 1 wherein said plurality of sublayers comprises a first sublayer which is bonded directly to said insulating layer and a second sublayer which is bonded onto said first sublayer.

11. The mold of claim 10 wherein said first sublayer comprises a material selected from the group consisting of an electroless copper, an electroless nickel-boron alloy and an electroless nickel-phosphorus alloy.

12. The mold of claim 11 wherein said second sublayer comprises an electroplated material selected from the group consisting of nickel, a nickel-phosphorus alloy, a nickel-palladium alloy, cobalt and chromium.

13. The mold of claim 11 wherein said second sublayer comprises a material selected from the group consisting of an electroless nickel-boron alloy and an electroless nickel-phosphorus alloy.

14. The mold of claim 11 wherein said second sublayer comprises a composite of electroless nickel and an abrasion resistant material selected from the group consisting of SiC, BN, Al_2O_3, WC and diamond.

15. The mold of claim 1 wherein said core includes means for cooling.

16. A multilayer mold for molding thermoplastic into finished parts comprising:
   a core;
   an insulating layer bonded to said core for slowing initial cooling of the thermoplastic during molding; and
   a skin layer bonded to the insulating layer and having the desired contour and surface characteristics of the finished part, said skin

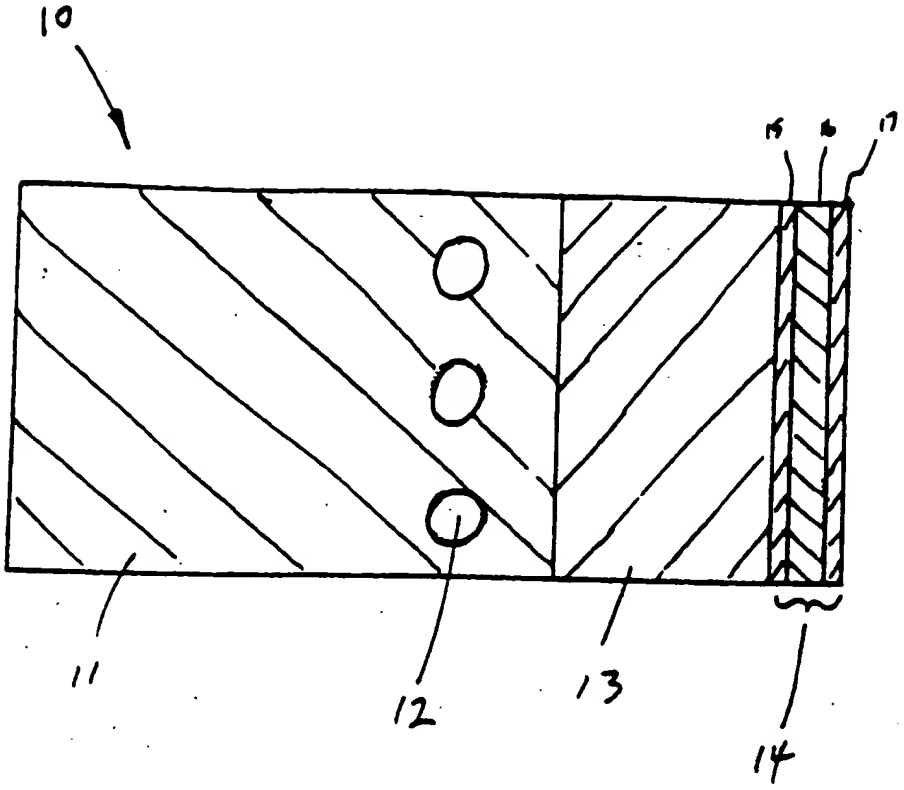

FIG. 1

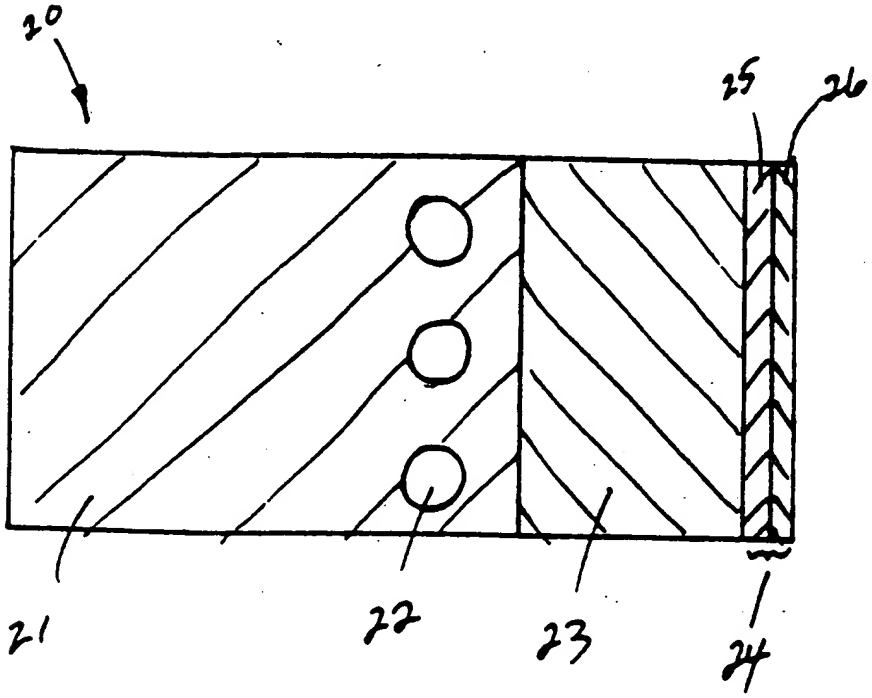

FIG. 2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 12 0141

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	US-A-4 225 109 (YOTSUTSUJI) * the whole document *	1-24	B29C33/56 B29C33/02
Y	EP-A-0 335 100 (GENERAL ELECTRIC CO.) * the whole document *	1-24	
Y	WORLD PATENTS INDEX Derwent Publications Ltd., London, GB; AN 79-760398 & JP-A-54 114 436 (KOBE STEEL K.K.) 6 Septenber 1979 * abstract *	1-24	
A	PATENT ABSTRACTS OF JAPAN vol. 4, no. 169 (M-43)(651) 21 November 1980 & JP-A-55 118 833 (YOSHINO KOGIOSHO K.K.) 12 September 1980 * abstract *	1,16	
A	PATENT ABSTRACTS OF JAPAN vol. 11, no. 259 (C-441)(2706) 21 August 1987 & JP-A-62 060 879 (NGK INSULATORS) 17 March 1987 * abstract *	1,16	TECHNICAL FIELDS SEARCHED (Int. Cl.5) B29C
A	DE-A-1 779 419 (HERBERTS & CO.) * the whole document *	1-24	
A	FR-A-2 319 477 (PLASTIC OMNIUM) * page 7 *	1,16	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	17 JANUARY 1992	R. SOZZI

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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